

NAME \_\_\_\_\_ DATE \_\_\_\_\_ PERIOD \_\_\_\_\_

## CHEMISTRY UNIT 2 MEASUREMENTS AND CALCULATIONS

*Broad Concept:* Physical and chemical properties can be used to classify and describe matter.

### Objectives (*Students will...*)

**Define** SI units for time, length, mass & temp.

**Explain** how adding a prefix changes a unit.

**Compare** the derived units for volume & density

**Express** numbers in scientific notation.

**Convert** between units using dimensional analysis

**Define & Compare** accuracy & precision

**Describe** the accuracy of experimental data using error and percent error.

**Apply** rules for significant figures to express uncertainty in measured and calculated values.

**Create** graphs to reveal patterns in data.

**Interpret** graphs

### NOTEBOOK -TABLE OF CONTENTS for Unit 2 (Chapters 2 in Modern Chemistry)

DATE	Assignment	Pages	√
1.			
2.			
3.			
4.			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

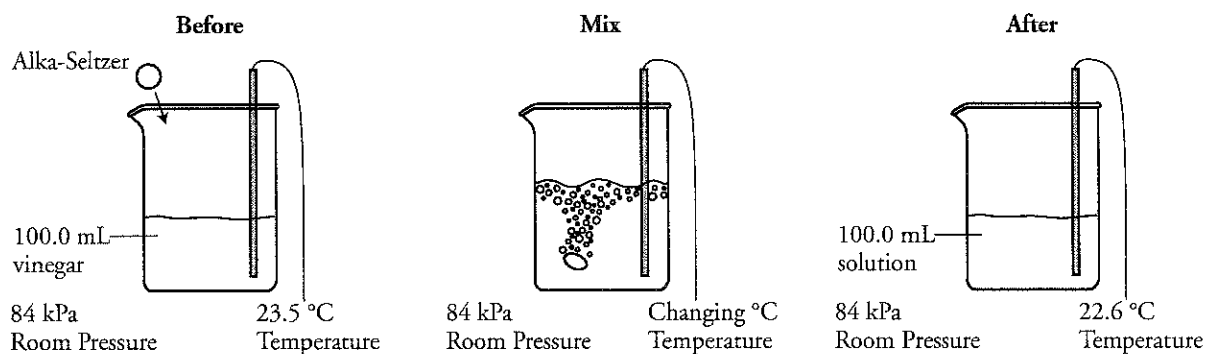
# Fundamentals of Experimental Design

What is measured during a controlled experiment?

## Why?

Working in the science lab can be a lot of fun. Mixing random chemicals and burning stuff just to see what happens can be entertaining (and possibly dangerous), but it doesn't lead to anything helpful to the scientific community. In order to be helpful to the community, a researcher's work in the lab must be systematic. A researcher usually asks a question and then designs an experiment to investigate that question. In this activity you will identify different types of variables that will help you design controlled experiments.

## Model 1 – Alka-Seltzer<sup>®</sup> and Vinegar



1. Briefly describe the reaction illustrated in Model 1 in one or more complete sentences.
2. Did the room pressure change as the reaction occurred? If yes, was there an increase or decrease?
3. What two pieces of evidence observed during the “mix” phase of the reaction suggest that a chemical change is taking place?
4. Did the solution temperature increase or decrease during the reaction?

## Model 2 – Results of Alka-Seltzer® Experiment

	Number of Alka-Seltzer Tablets	Volume of Vinegar (mL)	Room Pressure (kPa)	Initial Temp (°C) (Vinegar Solution)	Final Temp. (°C) (Final Mixture)
Trial 1	1	100.0	84	23.5	22.6
Trial 2	2	100.0	84	23.5	21.5
Trial 3	3	100.0	84	23.5	20.4
Trial 4	4	100.0	84	23.5	19.2
Trial 5	5	100.0	84	23.5	18.1

- Which trial in the Model 2 data table corresponds to the reaction illustrated in Model 1?
- Consider the five trials that produced the data in Model 2.
  - What variable was purposefully changed in the experiment?
  - What variable changed as a result of changing the variable listed in part a?
- What variable(s) shown in the Model 2 data table remained constant among all the trials?

## Model 3 – Boiling Points of Alcohols


Alcohol Name	Formula	Number of Carbons	Volume of Alcohol (mL)	Boiling Point (°C)	Room Pressure (kPa)
Methanol	CH <sub>3</sub> OH	1	75	64.7	101
Ethanol	CH <sub>3</sub> CH <sub>2</sub> OH	2	75	78.4	101
Propanol	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH	3	75	97.1	101
Butanol	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH	4	75	117.7	101
Pentanol	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH	5	75	137.9	101

- Describe the similarities and differences in the five alcohols used in the Model 3 experiment.
- Consider the experiment that produced the data in Model 3.
  - What variable was purposefully changed in the experiment?
  - What variable changed as a result of changing the variable listed in part a?
- What variable(s) in the Model 3 data table remained constant among all the trials?



## Read This!


When designing an experiment, you need to consider three types of variables. The **independent variable** is changed by the experimenter by design. This variable is sometimes called the “manipulated variable.” The **dependent variable** is what changes as a result of the change in the independent variable. This variable is sometimes called the “responding variable.” In some cases more than one dependent variable is considered. The third category involves **controlled variables**. These are variables that you think might change the outcome of the experiment, but since you are not studying them, you need to keep them constant in each trial.

-  11. Identify the independent, dependent, and controlled variables for the experiments that produced the data shown in Model 2 and Model 3.

Model Experiment	Variables		
	Independent	Dependent	Controlled
Alka-Seltzer® and Vinegar			
Boiling Points of Alcohols			

## Read This!

A well-written research question states the independent and dependent variables for an experiment. For example, a student investigated the effect of the deicer, magnesium chloride, on vegetation on the sides of highways. Her research question was, “What is the effect of magnesium chloride solution concentration on the growth of rye grass?”

-  12. Write a research question, using the format suggested in the Read This! box, for the experiments in Model 2 and 3.

Alka-Seltzer® and Vinegar —

Boiling Points of Alcohols—

13. A student wonders, “Will changing the volume of alcohol in a boiling point experiment change the boiling point of the liquid?” Identify the variables that should be considered in this experiment.

**Independent**

**Dependent**

**Controlled**

## Extension Questions

14. Many experiments designed to investigate the reaction of Mentos<sup>®</sup> with Diet Coke<sup>®</sup> have been documented on YouTube. Design and write an experiment that uses the knowledge gained in this activity to investigate this reaction. Include a research question; the independent, dependent and controlled variables; and a simple procedure.
15. Scientists may design an experiment with a **control group**, which is a set of organisms or samples that do NOT receive the treatment (the independent variable) that is being tested. Scientists can then compare normal changes in organisms or samples with those that might have occurred because of the treatment. The idea of a “control group” is not the same as a “controlled variable.” Suppose a scientist is doing an experiment to determine the effect of a cancer drug on mice with lymphoma.
- What are some of the variables the scientist should control in the experiment?
  - Describe the control group for this experiment.

## Unit 2: Matter & Measurement

### Section 1: The Process of Science

In 1928, Alexander Fleming noticed that bacteria he was studying did not grow in the presence of a yellow-green mold. In 1945, Fleming shared a Nobel Prize for Medicine with Howard Florey and Ernst Chain, who led the team that isolated penicillin.

#### What is science?

Science is a system of knowledge or a way of knowing that requires observation and experimentation.

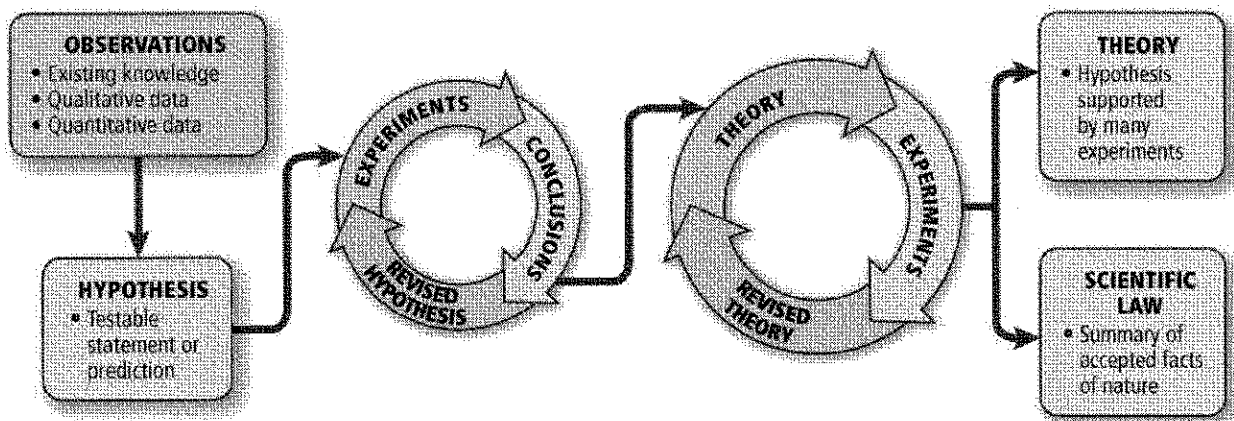
#### How do you DO science?

The scientific method is an organized process used by scientists to do research, and provides methods for scientists to verify the work of others.

#### Scientific Method

1. Make an observation.
2. Write a hypothesis.
3. Perform an experiment.
4. Analyze data and make conclusions.
5. Communicate results with other scientists.

#### What are the steps?



#### Making Observations

The act of gathering information.

Qualitative data – any observation (color changes, release of heat, etc.)

Quantitative data – any measurement you make (mass, volume, temperature, etc.)

Example: Suppose you try to turn on a flashlight and it doesn't light. An observation can lead to a question:

**What's wrong with the flashlight?**

## **Testing Hypotheses**

A **hypothesis** is a proposed explanation for an observation.

You guess that the batteries might be dead.

*If the batteries are out of power, **then** by replacing them, the flashlight will light up.*

Test your hypothesis by putting new batteries in the flashlight. If the flashlight lights, you can be fairly certain that your hypothesis is correct.

### **1. Designing Experiments**

An **experiment** is used to test a hypothesis. When you design experiments, you deal with **variables**, or **factors that can change**.

- You **change** the independent variable.
- You **observe** the dependent variable. (it *depends* on what you changed)
- The **controlled variables** do not change.

The data will support the hypothesis, or will cause it to be revised and retested.

### **Controlled Experiment**

- 1) **Control Group** – part of the experiment that represents standard conditions (receives no experimental treatment)
- 2) **Experimental Group** – the test group that receives experimental treatment

Example – You want to know the effect salt has on the freezing point of water.

Control group - water without salt

Experimental group - salt water.

### **Developing Theories**

Once a hypothesis is supported by repeated experimentation, it may become a theory.

- A **theory** is a well-tested explanation for a set of observations
- A theory may need to be revised to explain new observations or new experimental results

### **Scientific Laws**

- A **scientific law** summarizes the results of many observations and experiments.
- **Theories do NOT become laws!**
- A scientific law doesn't try to explain, explanation requires a theory.
- Successful **models** can help visualize difficult concepts and predict new observations.



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**Process of Science WS**

1. Science is a system of knowledge or a way of knowing that requires \_\_\_\_\_ and \_\_\_\_\_.

2. List the five steps of the scientific method in a possible order

- 1) \_\_\_\_\_
- 2) \_\_\_\_\_
- 3) \_\_\_\_\_
- 4) \_\_\_\_\_
- 5) \_\_\_\_\_

3. Observe the classroom. Make two qualitative observations, and two quantitative observations.

Qualitative Observations	Quantitative Observations

4. Write hypotheses for the following questions. Use the "If...then" format.

a) How does the weight of a magnet affect the number of paper clips it can hold?

\_\_\_\_\_  
\_\_\_\_\_

b) Does the color of the M&M affect the time it takes to dissolve in water?

\_\_\_\_\_  
\_\_\_\_\_

5. When should a hypothesis be revised?

\_\_\_\_\_

6. Maverick wants to find out whether or not Miracle Grow really makes plants grow faster. He takes two identical pots, puts 1/2 cup of dirt into each one, puts 3 pea plant seeds into each one, and tops each off with 1/2 cup more dirt. He waters the plants the same amount at the same time each day. The only difference is that one plant is watered with regular water, while the other is watered with water that has Miracle Grow in it.

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Controlled Variable(s) \_\_\_\_\_

\_\_\_\_\_

Control Group: \_\_\_\_\_

Hypothesis: \_\_\_\_\_

\_\_\_\_\_

7. Jack wants to find out which laundry detergent cleans the best. So, he takes a cotton sheet and cuts it up into equal squares. He stains four squares with chocolate, and four with grape juice. He washes one of each of the squares in each of the 3 detergents. One from each set of squares is washed in water alone. For each wash load, he used: the same amount of water, the same amount of detergent, and the same temperature of water.

Independent Variable: \_\_\_\_\_

Dependent Variable: \_\_\_\_\_

Controlled Variable(s): \_\_\_\_\_  
\_\_\_\_\_

Control Group: \_\_\_\_\_

Hypothesis: \_\_\_\_\_  
\_\_\_\_\_

8. Describe the difference between a scientific theory and a scientific law.

Theory - \_\_\_\_\_

Law - \_\_\_\_\_

9. Which of the following statements is true about scientific theories? Scientific theories...

- A. can become scientific laws.
- B. are never completely proven and can change.
- C. are proven and cannot be changed.
- D. are guesses without much evidence.

10. Which of the following questions is a scientific question that can be answered by observation and experimentation?

- A. Do palm trees grow taller in acidic soil?
- B. Is eating organically grown vegetables more responsible?
- C. Is soy milk better than cow milk?
- D. Should hunting for sport be banned, but hunting for food allowed?